CHEMICAL AND BIOLOGICAL FUNCTIONAL ASPECTS OF PASTA RICH IN DIETARY FIBER AND β-GLUCAN

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Abstract

Three new Varieties of Hull-less barley (Giza 129, 130 and Giza 131) were conducted to extract four barley fractions (A , B , C and D). Total Dietary Fiber (TDF), Soluble Dietary Fiber (SDF) and β-glucans were determined in all barely fraction. The level of TDF, SDF and β-glucan ranged between (13.4 and 30.9 %), (2.80 and 13.43%) and (1.78% and 9.90 %) respectively. The highest barley fraction of TDF, SDF and β-glucans mixed with wheat semolina to produce pasta by 30%: 70%,. The cooking characteristic and sensory evaluation led to the produced pasta have good functional quality compared with control. The biological study of produced pasta by rats indicated that the serum cholesterol decreased from (375.93 to 279.22 mg/dl), blood glucose from (210.4 to 76.20 mg/dl), total lipids (166.0 to 109.46 mg/dl) and triglcerides (108.19 to 69.13 mg/dl).

Key words: Functional pasta , barley fractions ,TDF, SDF, β-glucan .

INTRODUCTION

It is well known that barley contains higher level of β-glucan than other cereals. The new variety `Hull-less`` parley was used into many industries such as baby food, temese and drink industries. The barely bran that is a by-products of these industries represents 30-40% of total kernel weight is mainly used in animal feed. Jadhav, *et.al.* (1998) .

A high fiber diet has several health benefits including lower energy intake, prolonged satiety and a real effects related to increase feces bulk. Foods formulated with soluble dietary fibers usually lower serum cholesterol levels and postprandial blood glucose and insulin response; Bjorck, *et.al.*(2000) .

The dietary fibers lowered postprandial serum glucose levels at least by three mechanisms. First; they increase the viscosity of small intestine juice and hinder diffusion of glucose. Second, they bind glucose and decrease the concentration of available glucose in small intestine and the third one; they retard ά-amylase action. All of these previous mechanisms decrease the absorption rate of glucose and the concentration of postprandial serum glucose, ShiyiOu, *et.al.*(2001).

The aim of this study was to assess the possibility of using pearling by-product of Hull-less barley in human nutrition by formatting functional pasta making. The biological effect of this pasta in serum total cholesterol, lipids, trigycerides and blood glucose levels of rats was also considered.

MATERIALS AND METHODS

Materials

** The barley variety Giza 129 , Giza 130 and Giza 131 were obtained from the Barley Reasearch Dept. Field Corops Research Insti. ARC. Giza, Egypt.

** Wheat semolina was obtained from South Cairo Mills Company, Giza , Egypt.

** Male rats (35) Sprague Dawley were obtained from the Research Institute of Ophthalmology, Giza.

Preparation of barley fractions.

The barley grains were pearling to remove hull kernels. The dehull kernels were processed and fractionated according to the diagram in figure (1) as the method described by Knuckles *et. al.*(1992). Four fractions A ,B ,C and D were obtained.

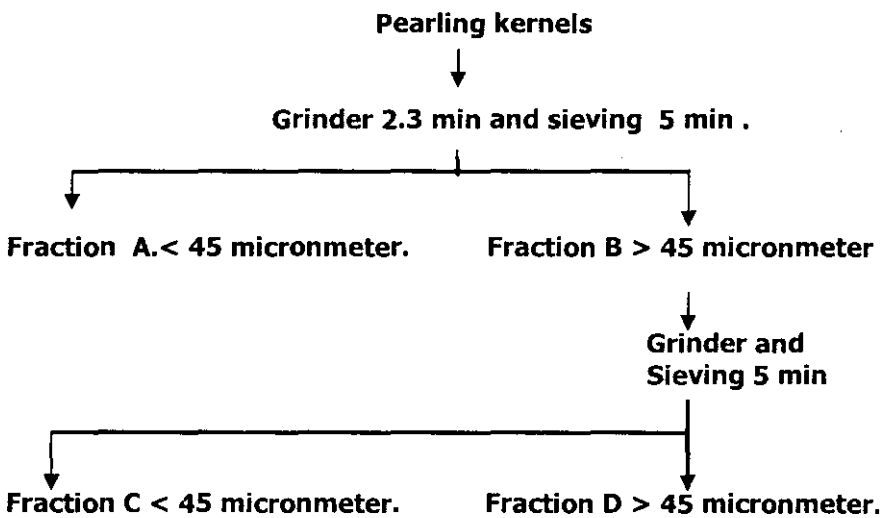

Figure (1) : Diagram of the barley fractions process .

Chemical analysis.

**The chemical composition of raw material and functional pasta (moisture, protein, ether extract, ash and carbohydrates) were determined according to the

methods describe in A.O.A.C.(1995). Digestibility of carbohydrates was calculated by different.

Digestibility of Carbohydrate = Total carbohydrates –Total Dietary Fiber (TDF).

****Determination of Total Dietary Fiber.**

Total dietary fiber (TDF); Insoluble dietary fiber (ISDF) and soluble dietary fiber (SDF) were determined according to the methods described by Mongeau and Brassard (1990).

****Determination of β-Glucan.**

Total β-Glucan; soluble and insoluble β-Glucan were determined according to the methods described by Carr, *et.al.*(1990).

Pasta processing.

The functional pasta produced by replacing 30% of durum wheat semolina with barley flour fractions (fraction D) rich in both β-Glucan and dietary fiber content. The moisture content was adjusted to 35% of each sample.

The pasta forming in DeMaco (De Francis Machine Corporation) Semi-Commercial Scale Laboratory extruder. After forming and separation of pasta and they placed on trays then dried at 60°C and 80% humidity for 4hr.

Pasta properties.

Cooking loss.

Dry matter losses during cooking was determined by A.A.C.C., (1995).

Cooking weight and percent of swelling.

The weight increase % was determined by cooking 10g pasta of each sample for 10 min in 300mL of boiling water. After cooking the samples were drained, rinsed and weight. On the other hand the volume increase % (swelling %) was determined using petroleum naphtha in measuring sample volume.

Sensory evaluation:

Organoleptic characteristics e.i. (Appearance, color, taste, mouthfeel and overall acceptability) of pasta cooked for 10min. were evaluated by ten panelists from Food Technology Research Institute. The score of each properties was 1 to 5 degree .as the method described by Taha *et al.,(* 1992).

Biological assay.

The biological evaluation was conducted using 35male rats (100-120g) using the animal house available at the Research Institute of Ophthalmology, Giza. After feeding on basal diet for two week as adaptation period, they were divided into two groups. The first non-diabetic one group (n=7 rats) fed on control diet and the second one (28 rats) was injected by streptozotocin (dissolved in citrate buffer at PH 7.2) into the leg muscle (50mg/kg body weight) according to David, *et.al.*(1997). The diabetic groups divided to four subgroups one group (n=7 rats) fed on pasta control and the other three groups fed on pasta mad from wheat semolina and barely fractions D G129, G130 and G131, respectively for two months.

Serum analysis.

Serum blood glucose, total cholesterol, total lipid and triglycerides of the experimental rats were determined using the methods describe by Barham and Trinder (1972), Schettler *et.al.*(1975), Zoeliner (1962) and. Trinder, (1969) , respectively.

Statistical analysis.

The obtained data were subjected to statistical analysis using analysis of Variance and Least Significant Different (L.S.D.) as reported by Waller and Duncan, (1969).

RESULTS AND DISCUSSION

Yield of barley fractions.

Data presented in Table (1) illustrate the hull of different hull-less barley that ranged between 5.99 to 6.70%. Giza barley 130 have highest content of fraction A (36.92 %) compared with the other two barley varieties. On the other hand, barley Giza 129 contains the highest B fraction upto 59.54%. The lowest fraction of barley was related to fraction C; ranged from 21.47 to 25.69 %.

Table 1. Yield of hulls and barley fractions.

Barley	Hulls yield	Barley fractions (g/100g dry basis)			
		A	B	C	D
Giza 129	6.70	33.66	59.64	25.69	34.93
Giza 130	5.23	36.92	57.85	21.47	36.38
Giza 131	5.99	34.16	58.85	23.43	35.42

Chemical composition of barley and barley fractions.

The chemical composition of barley and barley fractions (protein, ether extract, ash crude fiber and total carbohydrate) in Table (2). The protein content of barley ranged between 13.23 and 13.82%.,while crude fiber and total carbohydrates were ranged 3.46 to 3.83 % and 78.08 to 79.07% respectively.

Concerning the chemical composition of barley fractions, fraction A indicates the lowest protein content in relation to the other fractions and scoring a value ranged 12.17 to 12.29%. On contrary, it contains the highest level of total carbohydrates (80.08- 80.52%). The fraction D that represents 35% of all barley under investigation have high content of protein, ash and crude fiber (13.85- 14.05%), (2.13- 2.65%) and (4.25 – 4.43%); but its total carbohydrate come in the last order compared with other barley fractions (77.07 – 77.54%).

Table 2. Chemical composition of barley and barley fractions.

Barley and barely fractions	Components (g/100g dry basis).				
	Protein	Ether extract	Ash	Crude fiber	Total carbohydrates
Giza 129	13.82	2.61	1.84	3.65	78.08
A	12.23	1.82	1.75	3.53	80.67
B	13.91	1.96	1.86	3.60	78.67
C	13.50	1.73	2.00	3.00	78.72
D	14.05	2.04	2.13	4.27	77.51
Giza 130	13.67	2.40	1.99	3.83	78.11
A	12.17	1.84	1.85	3.62	80.11
B	13.72	2.07	2.05	4.17	78.51
C	12.66	1.94	1.97	3.79	79.10
D	13.85	2.00	2.65	4.43	77.07
Giza 131	13.23	2.35	1.89	3.46	79.07
A	12.29	1.89	1.78	3.14	80.80
B	13.56	1.74	2.13	3.48	78.90
C	12.98	1.85	1.98	3.90	79.48
D	13.88	2.13	2.20	4.25	77.54

Dietary fiber content of barely and barley fractions.

Data in Table (3) reveled that the Giza 130 has highest percent of total dietary fiber (TDF) and soluble dietary fiber (SDF) compared with two other varieties Giza 131 and Giza 129. The concentration of TDF and SDF were (17.40% and 7.56%), (15.20% and 6.38%) and (13.40% and 5.62%) respectively. The insoluble dietary fiber (ISDF) showed similar trend of TDF and SDF as seen in the same table.

The results of TDF, SDF and ISDF of barley fractions were also reported in Table (3). Fraction D has highest amount of TDF, SDF and ISDF flowing by fraction B , fraction C and fraction A of all barley study. The fraction D from Giza 130 have 30.90% TDF. Also, the SDF was 13.43% or 4.88 g/100g whole barley Giza 130. While the fraction A have less percent of TDF, SDF and ISDF of all barley under investigation. These results maybe due to the pentosan component concentrate in the cell wall of barley starchy endosperm. Marconi, *et.al.*(2000) fount that the TDF of whole barley was ranged between (13.1 –16.1%); while it was (12.9 – 31.4%) barley fractions.

Beta-glucan content of barely and barely fractions.

Data presented in Table (3) show total β-glucan , soluble and insoluble β-glucan content of barley fractions. It is clear that fraction D of the three barley study (Giza 129 ,130 and 131) contain the highest content of total β-glucan and β-glucan fractions. Values obtained were ranged between (8.22 % to 9.90%), (4.47 to 5.25%) and (3.75 to 4.69%) respectively. Fractions A and C have the lowest content of total β-glucan and β-glucan fractions compared with fractions B and D. These results maybe due to the concentrate of β-glucan in cell walls of starchy endosperm of barley. These results the same trend with that found by Marconi, *et.al.* (2000).

From the previous results, it could be concluded that barley Giza 130 is characterized by high content of total dietary fiber and its fraction as wellas total β-glucan and its fractions compared with Giza 129 and Giza 131. The fractions D have more than 60% of the (TDF, SDF and β-glucan) so that it was used to produce functional pasta by substituting 30% of wheat semolina with flour from fraction D.

Chemical composition of produced pasta.

The chemical compositions of produced pasta are given in Table (4). These results reveled that the protein content slightly increase of produced pasta compared with control. The substitution of barley fraction D caused increase of ash, ether extract and crude fiber. Also, the substituting of wheat semolina with barley fraction caused increasing of β-glucan, TDF, SDF and ISDF. But the carbohydrate digestibility and calories /100g were decrease compared with pasta control from (80.42 to 69.2 %) and (384.08 to 348.48), respectively.

Table 3. Dietary fiber and B-glucan content of barley and barley fractions (g/100g dry basis).

Barley and barley fractions	Dietary fiber						B-glucan					
	TDF		SDF		ISDF		Total β-glucan		Soluble B-glucan		Isoluble β-glucan	
	Barley fractions	Whole Barley	Barley fractions	Whole Barley	Barley fractions	Whole Barley	Barley fractions	Whole Barley	Barley fractions	Whole Barley	Barley fractions	Whole Barley
Giza 129	13.40	13.4	5.62	5.62	7.78	7.78	4.15	4.15	2.10	2.10	2.05	2.05
A	7.00	2.45	2.80	0.95	4.20	1.50	1.80	0.60	0.86	0.28	0.93	0.32
B	18.39	10.95	7.83	4.67	10.56	6.28	5.95	3.55	3.05	1.82	2.90	1.73
C	12.74	3.53	3.97	1.02	8.77	2.41	2.64	0.68	1.02	0.26	1.62	0.42
D	22.24	7.42	10.44	3.65	11.80	3.87	8.22	2.87	4.47	1.56	3.75	1.31
Giza 130	17.40	17.40	7.56	7.56	9.84	9.84	4.68	4.68	2.49	2.49	2.19	2.19
A	9.01	3.32	3..92	1.44	5.09	1.88	1.78	0.65	0.97	0.35	0.81	0.30
B	24.34	14.08	10.58	6.12	13.76	7.96	6.96	4.03	3.69	2.14	3.27	1.89
C	12.57	2.70	5.74	1.23	6.83	1.47	2.06	0.43	1.07	0.23	3.06	0.93
D	30.90	11.38	13.43	4.88	17.47	6.50	9.90	3.60	5.25	1.91	4.35	1.69
Giza 131	15.20	15.20	6.38	6.38	8.82	8.84	4.51	4.51	2.40	2.40	2.11	2.11
A	7.66	2.61	3.05	1.04	4.61	1.57	1.55	0.52	0.78	0.26	0.77	0.26
B	21.39	2.59	9.07	5.34	12.32	7.25	6.82	3.98	3.63	2.14	3.19	1.84
C	11.82	2.76	3.41	0.81	8.41	1.95	2.90	0.68	2.13	0.50	1.77	0.18
D	27.75	9.83	12.81	4.53	14.94	5.30	9.32	3.30	4.63	1.64	4.69	1.66

Table 4. Chemical composition of functional pasta.(g/100g dry basis)

Constituents under investigation	Control	Functional Pasta.		
		Giza 129	Giza 130	Giza 131
Protein.	13.08	13.44	13.50	13.27
Ash.	0.85	1.21	1.25	1.24
Ether extract.	1.12	1.62	1.64	1.60
Crud fiber.	0.95	1.87	1.92	1.90
Carbohydrate digestibility.	80.42	72.68	69.93	71.17
B-glucan.	0.35	2.72	3.22	3.04
TDF	3.57	9.18	11.76	10.82
ISDF	1.66	4.70	6.40	5.64
SDF	1.91	4.46	5.30	5.18
Calories kcal/100gm	384.08	359.06	348.48	352.16

Cooking quality of functional pasta .

The effect of substitution of wheat semolina with fraction D of different barely study on cooking properties in terms of weight, swelling and cooking loss was reported in Table (5). The barley fractions lead to a significant increase of cooked weight and swelling of functional pasta compared with control. Such trend maybe due to the high levels of TDF and β-glucan in barley fraction and so increasing water holding capacity of pasta. The highest swelling and cooked weight of pasta prepared from barley Giza 130 flowed by Giza 131 and Giza 129. The cooking loss was slightly increase by substitution barley fraction compared with pasta control a trend which maybe due to the wheat semolina is more available to make gluten compared with barley protein. Abo-Elnaga (1995) who found that the high fiber pasta increasing of volume and weight compared with pasta control

Organoleptic characteristics.

Organoleptic characteristics e.i.(appearance, color, taste, mouthfeel and overall acceptability) of the produced pasta under investigation were evaluated by 10 panelists. Data in Table (5) proved that substituting of wheat semolina by barley fraction a non-significant effect of pasta taste, mouthfeel; while it decreased significantly pasta appearance, color and overall acceptability compared control.

Table 5 : Cooking properties and organoleptic characteristics of different prepared pasta.

Pasta prepared from	Properties of pasta. %			Organoleptic properties. (At of 5 points)				
	Cooking weight	Cooking loss	Swelling	Appearance	Color	Taste	Mouthfeel	Overall acceptability
Control	205.77^{d}	8.95^{c}	210.64^{d}	4.88^{a}	5.00^{a}	4.90^{a}	4.83^{a}	4.86^{a}
Barley:								
Giza 129	216.65^{c}	10.40^{a}	228.31^{c}	4.69^{b}	4.67^{b}	4.79^{a}	4.81^{a}	4.70^{b}
Giza 130	225.09^{a}	9.83^{b}	240.25^{a}	4.85^{a}	4.76^{b}	4.88^{a}	4.90^{a}	4.87^{a}
Giza 131	220.50^{b}	10.68^{a}	231.16^{b}	4.75^{b}	4.69^{b}	4.80^{a}	4.84^{a}	4.78^{ab}
L.SD	**0.8421**	**0.3734**	**0.9856**	**0.1382**	**0.1103**	**0.135**	**0.1023**	**0.1041**

Biological effect of produced pasta on serum glucose, total cholesterol, lipids and triglycerade of experimental rats.

Table (6) shows the effect of using substitution pasta on the serum glucose of rats. The data revealed that serum glucose of the normal control amounted in (82.20 mg/dl) while in the diabetic control it was (199.18 mg/dl). Feeding on pasts substituted with 30% fraction D from Giza 129, 130,131 caused gradually decrease of glucose levels after 3 weeks, it ranged between (139.92 and 164.10 mg/dl). By the end of two months there was no difference compared with normal control. But pasta substituted with fraction D from Giza 129 showed significantly increased compared with normal control in the end of experimental. These results maybe due to fraction D from barley Giza 130 and Giza 131 contains higher levels of β- glucan , TDF and SDF compared with barley Giza 129. Such trend may increase the viscosity of small intestine juice and hinder diffusion of glucose. Such conclusion is matched with Wood *et.al.* (2000) and Shiyi ou *et.al.* (2001) who concluded that diets rich in dietary fiber decreased glucose uptake into the blood serum noted similar results.

The data presented in Table (6) show the effect of fed pasta richen β-glucan, TDF and SDF on serum total lipid, total cholesterol and triglycrides of experimental rats. These data led to significant changes in all treatments under studies in serum total lipid, total cholesterol and triglycrides compared with diabetic control or healthy

rats. These results maybe explained by that barley fraction has high content of β-glucan and SDF. So these fractions cause increase viscous membrane and prevention of back- absorption of bile acids in the small intestine, which lead to increase the use of cholesterol for bile acid synthesis in the liver. Similar results were reported by Louz (1997) , Kahlon and Chow (1997), Malkkl, (2001) and Abdel- Kader et al (2002) who reported that the decrease in blood cholesterol level by the polysaccharides were probably due to the following successive events: the decrease in blood glucose, the decrease in HMG.COA reeducates activity and finally the decrease in cholesterol synthesis.

Table 6. Effect of using different pasta on glucose levels, Total cholestrol, lipid and Triglycerides of rats.

Tested pasta	Glucose levels (mg/dl)				Serum content (mg/ dl)		
	A	B	C	D	Total cholesterol	Total lipid	Triglycerides
Normal control	81.41^{a}	81.95^{d}	82.01^{f}	82.20^{c}	281.58^{c}	108.89^{c}	70.50^{c}
Diabetic control	77.50^{c}	199.18^{c}	212.28^{a}	215.18^{a}	375.93^{a}	166.20^{a}	108.19^{a}
Barley:							
Giza 129	81.06^{a}	210.42^{a}	164.10^{b}	92.66^{b}	284.76^{b}	118.00^{b}	73.76^{b}
Giza 130	78.50^{b}	198.71^{c}	139.92^{d}	79.90^{d}	279.22^{d}	109.46^{c}	69.13^{d}
Giza 131	80.50^{a}	202.14^{b}	154.26^{c}	82.69^{c}	280.01^{c}	110.13^{c}	70.43^{c}
L.SD	0.7351	0.9841	0.8246	0.9723	0.9439	0.9439	0.9635

A - 48 hours before the injection by STZ streptozotocin .

B- 72 hours after the injection by STZ .

C – After three weeks

D – After two months.

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التاثيرات الحيوية الوظيفية للمكرونة الغنية بالألياف الغذائية والبيتا جلوكان

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معهد بحوث تكنولوجيا الأغذية – مركز البحوث الزراعية –جيزة.

يهدف هذا البحث الى استخدام بعض الأصناف الجديدة من الشعير العاري وهى (جيزة ١٢٩- ١٣٠- ١٣١) فى الحصول على عدة طبقات من نفس الحبة ((A ,B ,C ,D) وتقدير محتوى كل طبقة من المكونات الوظيفية وخاصة الألياف الغذائية الكلية والألياف الغذائية الذائبة وكذلك البيتاجلوكان. وأوضح التحليل الكيميائي لأصناف الشعير والطبقات الناتجة ان الألياف الغذائية الكلية تتراوح بين ١٣,٤ الى ٣٠,٩% . بينما كانت والألياف الغذائية الذائبة (٢,٨ - ١٣,٤٣ %) و البيتا جلوكان (١,٧٨ - ٩,٩٠ %).

- كما أظهرت النتائج ان أغنى هذه الطبقات بالمكونات الوظيفية هو الطبقةD. من الأصناف الثلاثة (جيزة ١٢٩- ١٣٠- ١٣١)لذلك تم استخدامها مع سيمولينا القمح بنسبة (٣٠ : ٧٠) لتصنيع مكرونة. وكذلك تقدير صفات الطبخ للمكرونة الناتجة وذلك بالمقارنة بالكنترول. أظهرت نتائج التقييم الحسي وخصائص الطبخ أن المكرونة المصنعة ذات جودة عالية .

-كما أوضحت التجارب بواسطة الفئران أن المكرونة المصنعة أدت إلى تخفيض مستوى الكلوسترول فى الدم (من ٣٧٥,٩٣ - ٢٧٩,٢٢ مجم/ديسلتر) و سكر الدم (٢١٠,٤ - ٧٦,٢مجم/ديسلتر) والدهون الكلية من (١٦٦,٠-١٠٩,٤٦مجم/ديسلتر) وكذلك الجلسريدات الثلاثية من (١٠٨,١٩-٦٩,١٣مجم/ديسلتر)